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ARMY RESEARCH CONCERNS IN ENGINE SEALING

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The Army Propulsion Directorate is primarily concerned with small engine technology, where sealing performance is most critical. Tip leakage and secondary flow losses have a much greater performance impact on small engine aero-components than on large engines. A brief survey and critique of presently employed sealing concepts is presented. Some recent new research thrusts that show promise for substantial improvement are discussed. An especially promising approach for small engine applications is brush seals. Brush seal concepts are being considered for outer air seal and secondary airflow system seal locations.

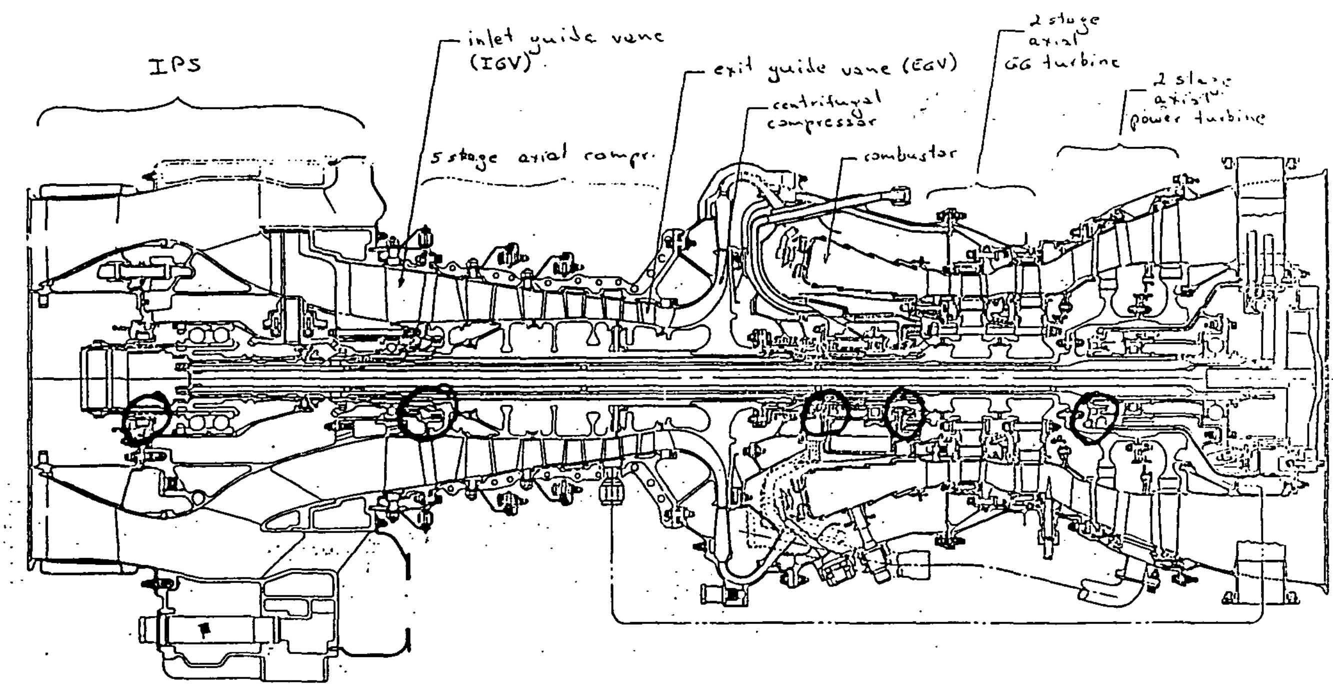
PRIMARY FUNCTIONS OF ENGINE SEALING

- ISOLATE BEARING COMPARTMENTS FROM ENGINE E
- REDUCE EFFICIENCY LOSSES CAUSED BY LEAKAGE
- CONTROL SECONDARY AIRFLOW SYSTEM
  - COOLING
  - PURGE
  - BUFFER
  - PRESSURE BALANCE

SHAFT SEALS

- ISOLATE BEARING CAVITIES FROM ENGINE ENVIRONMENT
- PREVENT LOSS OF LUBRICANT

T700 Turboshaft Engine



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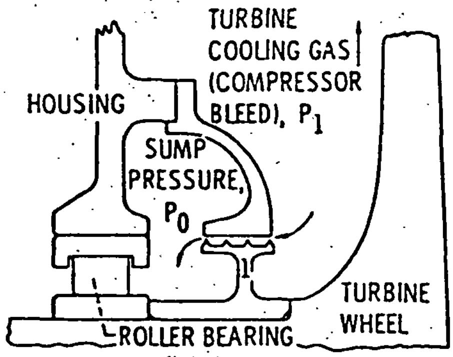
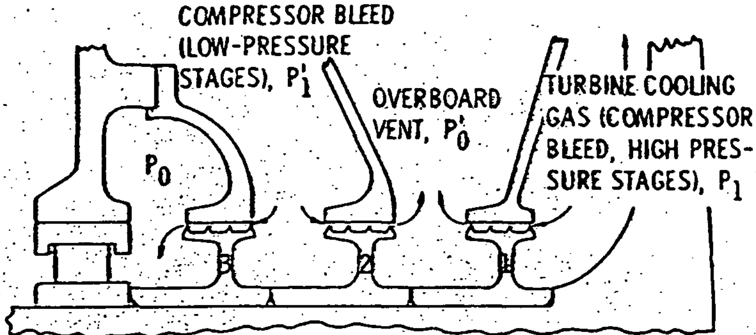
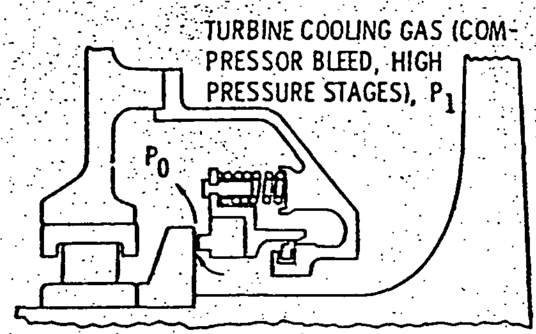


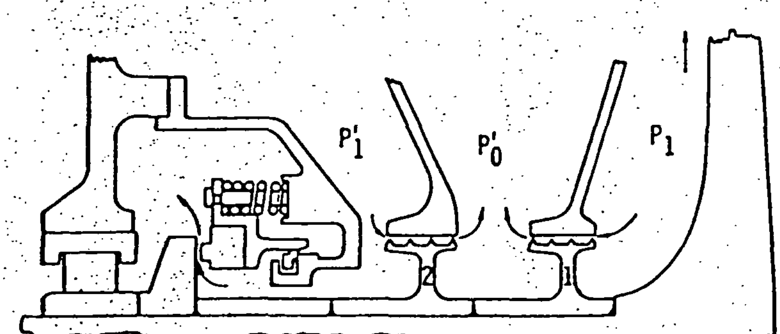
(a) SINGLE LABYRINTH, EARLY ENGINES.



(b) MULTIPLE LABYRINTH FOR HIGH-TEMPERATURE HIGH-PRESSURE TURBINE COOLING GAS.



(c) CONVENTIONAL FACE SEAL



(d) CONVENTIONAL FACE SEAL WITH LABYRINTH SEAL FOR HIGH-TEMPERATURE, HIGH-PRESSURE COOLING GAS.

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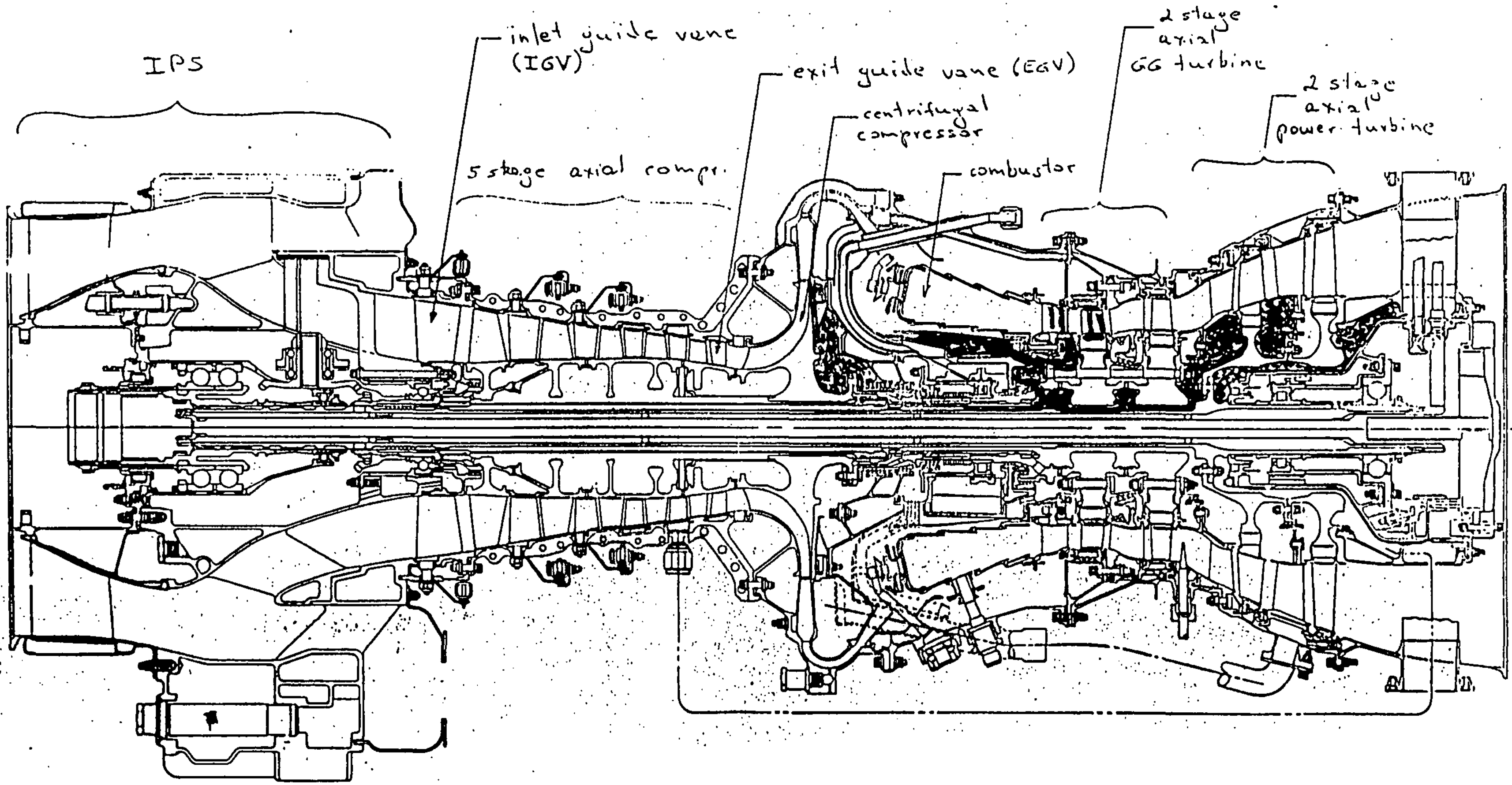
SUMMARY - SHAFT SEALS

- MUST FUNCTION AS SEALS - NOT FLOW RESTRICTORS
- RUB CAPABILITY AND TEMPERATURE CAPABILITY OF MATERIALS ARE TECHNICAL BARRIERS
- NEW CONCEPTS BEING EXAMINED
  - "BRUSH" SEALS
  - FLUIDIC SEALS

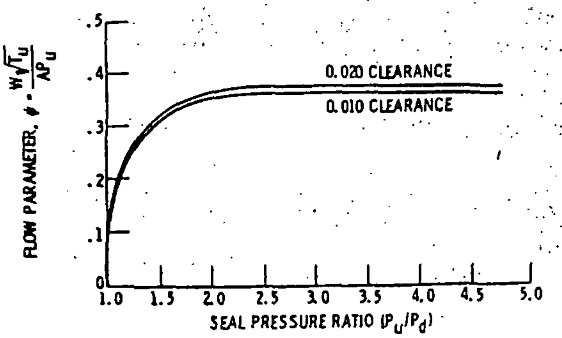
INNER AIR SEALS CONTROL SECONDARY AIRFLOW SYSTEM

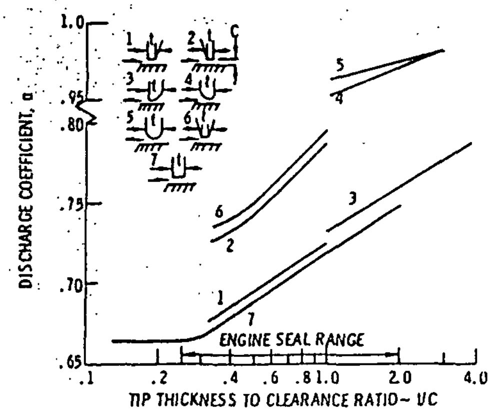
- COOLING AIR TO HOT SECTION COMPONENTS
- DISK CAVITY PURGE AIR
- PRESSURE BALANCE SYSTEM
- SHAFT SEAL BUFFER AIR

T700 Turboshaft Engine



MAINTAINING MINIMUM CLEARANCE AND KNIFE-EDGE GEOMETRY ARE CRITICAL TO LABYRINTH SEAL PERFORMANCE



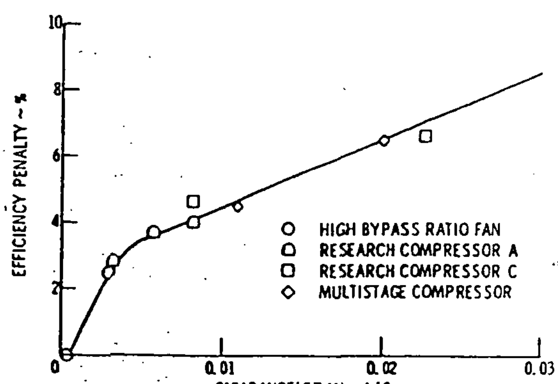


SUMMARY - IAS

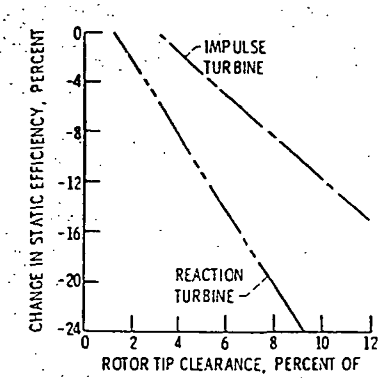
- CLEARANCE PREDICTION AND CONTROL ARE CRITICAL TO RELIABLE FUNCTION OF IAS SYSTEM
- EXISTING FLOW MODELS ARE CRUDE, SEMI-EMPERICAL
- MATERIAL REQUIREMENTS SIMILAR TO THOSE FOR OAS
- STRUCTURAL STABILITY CONCERNS AND GUIDELINES EXIST
  - AEROELASTIC INSTABILITIES
  - THERMOELASTIC INSTABILITIES

OUTER AIR SEALS REDUCE BLADE TIP LOSSES

- OVER THE TIP LEAKAGE
- INDUCED SECONDARY FLOW LOSSES



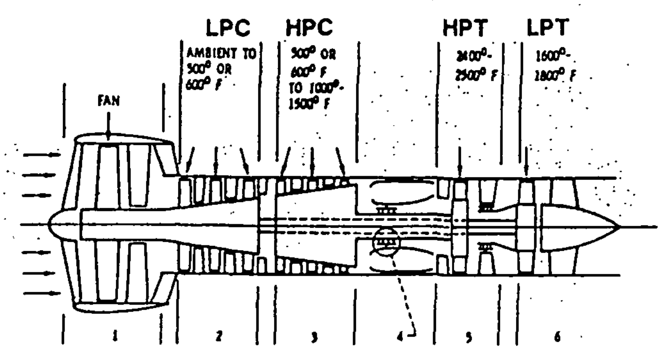
- Typical compressor efficiency penalty as a function of blade clearance-to-span ratio



- Effect of rotor tip clearance on performance for various turbines

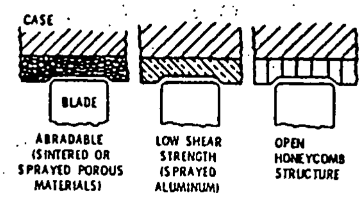
OAS MATERIAL REQUIREMENTS

- ABRADABILITY
- EROSION RESISTANCE
- CAPACITY TO SURVIVE IN ENGINE ENVIRONMENT



TYPICAL SEAL MATLS:
1 SILICONE RUBBER; Al HONEYCOMB; EPOXY
2 SPRAYED Al; SPRAYED NICKEL-GRAPHITE; SILICONE RUBBER; FIBERMETAL
3 HASTELLOY-X FIBERMETAL; SPRAYED NICKEL-GRAPHITE; SPRAYED NICHROME WITH ADDITIVES
4 LABYRINTH SEALS: Ag BRAZE; FIBERMETAL; HONEYCOMB
5 CAST SUPERALLOY (COOLED); SINTERED HIGH TEMP METALS; CERAMICS (EXPERIMENTAL)
6 SUPERALLOY HONEYCOMB

GENERAL CLASSES OF ABRADABLE MATERIALS



SUMMARY - OAS

- RETENTION OF MINIMUM TIP CLEARANCES IS CRITICAL TO THE EFFICIENCY OF AERO-COMPONENTS
- OAS SYSTEM MUST MEET CONFLICTING DEMANDS OF:
  - ABRADABILITY
  - EROSION RESISTANCE
  - DURABILITY
- OAS TECHNOLOGY HAS FOCUSED HEAVILY ON MATERIAL APPROACHES